TITLE OF THE INVENTION

FOCUSING DEVICE AND METHOD

FIELD OF THE INVENTION

5   The present invention relates to a focusing

device and method and, more particularly, to a focusing

device and method, which are used in an image sensing

apparatus such as a video camera, digital still camera,

or the like, for setting an appropriate in-focus state.

10

BACKGROUND OF THE INVENTION

As a conventional automatic focus adjustment

operation used in a video equipment such as a video

camera or the like, a so-called "hill-climbing

15   operation" is known. In this operation, a

high-frequency component in an image signal obtained

from an image sensing element such as a CCD is

extracted, and focus adjustment is done by driving a

focusing lens to maximize the high-frequency component.

20   Since the focus adjustment system based on this

"hill-climbing operation" makes focus detection based

on the sharpness of an object image, it can accurately

adjust the focus irrespective of the object distance,

i.e., even when an object is located at a far or

25   closest distance position.

As conventional auto-focusing (to be abbreviated to "AF" hereinafter) based on the hill-climbing operation, an integration AF method that integrates, within a predetermined distance measurement range of a frame, image signal components which have undergone a high-pass filter process for extracting a high-frequency component and uses an integrated signal in focusing control is prevalently used. Since the integration AF method integrates extracted high-frequency components within the distance measurement range and uses the integrated signal, it is excellent in AF stability, and can easily obtain an optimal in-focus point.

Fig. 14 is a block diagram showing an arrangement of a video camera system adopting the conventional integration AF method.

Referring to Fig. 14, reference numeral 101 denotes a stationary first lens group; 102, a zoom lens for zooming; 103, an iris for adjusting the quantity of light; and 104, a stationary second lens group. Reference numeral 105 denotes a focus compensation lens (to be referred to as a "focus lens" hereinafter) which has a function of compensating for movement of a focal plane upon zooming, and a focus adjustment function.

Reference numeral 106 denotes a CCD as an image sensing element. Reference numeral 107 denotes a

CDS/AGC which performs sample-and-hold operation and amplifies the output from the CCD 106, and the gain of which is adjusted by a signal from a camera controller (microcomputer) 114 to be described later. Reference

5   numeral 108 denotes an A/D converter for converting an analog signal from the CDS/AGC 107 into a digital signal; and 109, a camera signal processing circuit. The output signal from the camera signal processing circuit 109 is recorded on a recording medium such as a

10   magnetic tape, memory, or the like (not shown).

Reference numeral 110 denotes a timing signal generator for supplying various drive pulses and timing pulses to the respective sections of the camera, such as the CCD 106, CDS/AGC 107, and the like.

15   Reference numeral 111 denotes a zoom lens driver for driving the zoom lens 102; 112, an iris driver for driving the iris 103; and 113, a focus lens driver for driving the focus lens 105. The drivers 111 to 113 respectively drive motors included therein in

20   accordance with signals from the camera controller 114.

Reference numeral 120 denotes a focus evaluation value processor, which has a high-pass filter 121 for extracting a predetermined high-frequency component from a luminance signal output from the A/D converter

25   108, a distance measurement range gate 122 for extracting only signal components within a

predetermined distance measurement range from a frame, a line peak hold circuit 123 for holding peaks of the signal components extracted by the distance measurement range gate 122 in units of horizontal scan lines, and

5   an integrator 124 for integrating peak values of the peak-held scan lines. The integrated value is called an "integrated focus evaluation value".

The value of the integrator 124 is reset for each frame, and the integrator 124 can compute the

10   integrated focus evaluation value for each frame. The integrated focus evaluation value is input to the camera controller 114, which drives the focus lens 105 via the focus lens driver 113 to maximize the integrated focus evaluation value.

15   In the prior art, the peak values of the peak-held scan lines are integrated. Alternatively, the signal components may be integrated without holding peaks, or peak values may be held in units of a plurality of horizontal scan lines, and the held values

20   may be integrated.

The output luminance signal from the A/D converter 108 is also input to an exposure evaluation value processor 130, which generates an evaluation value for controlling exposure from signal components

25   of a frame and supplies it to the camera controller 114. The camera controller 114 drives the iris 103 based on

the exposure evaluation value to obtain an optimal

exposure value. A key unit 115 is connected to the

camera controller 114, and various kinds of key

operation information of the camera unit such as a zoom

5   key for operating the zoom lens 102 and the like are

output to the camera controller 114. For example, when

the user has pressed the zoom key, the camera

controller 114 drives the zoom lens 102 via the zoom

lens driver 111 to obtain a desired zoom ratio (focal

10   length).

However, since the integration AF method controls

to obtain the highest average contrast within a frame,

although no problem is posed for a normal object

focusing performance impairs for an image of a

15   high-luminance object or a point light source in a

night scene (to be referred to as a "peak image"

hereinafter).

Fig. 15 shows an example of the integrated focus

evaluation value of a normal object, and Fig. 16 shows

20   an example of the integrated focus evaluation value of

a peak image. In the normal object, since an in-focus

point and a peak value of the integrated focus

evaluation value appear at an identical position P0, as

shown in Fig. 15, and no problem is posed. However, in

25   the peak image, an in-focus point and a peak of the

integrated focus evaluation value do not appear at the

same position, and the peak of the integrated focus
evaluation value appears at a slightly offset focus
lens position PB, as shown in Fig. 16.

In case of an image of a point light source in a
night scene as a typical peak image, the integrated
focus evaluation value assumes a larger value in an
out-of-focus state shown in Fig. 18 than a perfect
in-focus state shown in Fig. 17. Note that Figs. 17
and 18 show examples of images that appear on the frame
upon sensing a peak image. In this manner, a peak of
the integrated focus evaluation value appears at a
focus lens position offset from an actual in-focus
point. In such case, since the camera controller 114
controls the focus lens 105 to a position where the
integrated focus evaluation value has a peak, the focus
lens 105 is controlled to the focus lens position PB
shown in Fig. 16. As a result, the obtained image is
out of focus.

As an alternative to the integration AF method, a
peak AF method that uses a maximum peak value within a
predetermined distance measurement range from luminance
signal components of a frame that has undergone a
high-pass filter process for extracting high-frequency
components is known. Fig. 19 is a block diagram
showing the arrangement of a video camera system that
adopts the conventional peak AF method.

The video camera shown in Fig. 19 has substantially the same arrangement as that of the video camera shown in Fig. 14, except that the arrangement of the focus evaluation value processor 120 is modified to

5   obtain the maximum value of high-frequency components of the luminance signal within the distance measurement range. Referring to Fig. 19, the maximum value of high-frequency components of the luminance signal within the distance measurement range, which is output

10 from a focus evaluation value processor 120' is called a "peak focus evaluation value".

Fig. 20 shows a peak focus evaluation value in a peak image which is hard to focus upon adjustment by integration AF. For the purpose of comparison with

15 integration AF, Fig. 20 also shows the integrated focus evaluation value. As can be seen from Fig. 20, the peak focus evaluation value becomes maximal at a correct in-focus point even in a peak image. Figs. 21A and 21B respectively show a luminance signal for one

20 horizontal line of a portion indicated by LA in Fig. 17, and the output of a high-pass filter of an in-focus image of a point light source. Figs. 22A and 22B respectively show a luminance signal for one horizontal line of a portion indicated by LB in Fig. 18, and the

25 output of a high-pass filter of an out-of-focus image of a point light source.

In this manner, even in a peak image with a
saturated luminance signal, since in-focus and
out-of-focus images have different leading edges of
luminance signals, the output from the high-pass filter

5   differs in correspondence with these images, thus
allowing correct in-focus point detecting. In the peak
AF method, a correct in-focus point can be detected in
a peak image.

However, since the peak focus evaluation value is

10   smaller than the integrated focus evaluation value, the
peak AF method has poor stability for a normal object
compared to the integration AF method, and AF often
becomes unstable under the influence of, e.g., panning.
Since it is controlled to obtain the highest

15   average contrast within a frame in the integration AF
method, no problem is posed in a normal object, but
focusing performance impairs in a peak image.

SUMMARY OF THE INVENTION

20   The present invention has been made in
consideration of the above situation, and has as its
object to provide an automatic focus adjustment device
and method which can accurately detect an in-focus
point for not only a normal image but also a peak image.

25   According to the present invention, the foregoing
object is attained by providing an apparatus

comprising: (A) a photo-receiving device for receiving light from an object and converting it into an electrical signal; and (B) a focus adjusting device for forming a first adjustment signal by performing a predetermined integration operation on a predetermined frequency component of an image signal obtained by the photo-receiving device and forming a second focus adjustment signal, different from the first focus adjustment signal, from a peak value of a predetermined frequency component of the image signal obtained by the photo-receiving device, wherein the focus adjustment apparatus applies at least one of the first and second focus adjustment signals to focus adjustment on the basis of a luminous state of the object.

Further, the foregoing object is also attained by providing an apparatus comprising: (A) a photo-receiving device for receiving light from an object; and (B) a focus adjusting device performing an operation for focus adjustment, wherein the focus adjusting device performs the operation depending upon determination whether or not an object image has a luminous state judged as a peak image from a photo-received signal on the basis of the photo-receiving device.

Furthermore, the foregoing object is also attained by providing a focus adjusting method

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comprising: converting light from an object into an
image signal, forming a first adjustment signal by
performing a predetermined integration operation on a
predetermined frequency component of the image signal,
5   forming a second focus adjustment signal, different
from the first focus adjustment signal, from a peak
value of a predetermined frequency component of the
image signal, applying at least one of the first and
second focus adjustment signal to focus adjustment on
10   the basis of a luminous state of the object.

Further, foregoing object is also attained by
providing a focus adjusting method comprising:
performing an operation for focus adjustment depending
upon determination whether or not an object image has a
15   luminous state judged as a peak image on the basis of a
photo-received signal of light of the object.

Further, foregoing object is also attained by
providing a computer program product comprising:
converting light from an object into an image signal,
20   forming a first adjustment signal by performing a
predetermined integration operation on a predetermined
frequency component of the image signal, forming a
second focus adjustment signal, different from the
first focus adjustment signal, from a peak value of a
25   predetermined frequency component of the image signal,
applying at least one of the first and second focus

adjustment signal to focus adjustment on the basis of a luminous state of the object.

Further, foregoing object is also attained by A computer program product comprising: performing an operation for focus adjustment depending upon determination whether or not an object image has a luminous state judged as a peak image on the basis of a photo-received signal of light of the object.

Other features and advantages of the present invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the figures thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

Fig. 1 is a block diagram showing an arrangement of a video camera system that adopts a focus adjustment method according to a first embodiment of the present invention;

Fig. 2 is a flow chart showing a focus adjustment control sequence executed by a camera controller according to the first embodiment of the present invention,;

5   Fig. 3 is a graph for explaining a peak image discrimination scheme according to the first embodiment of the present invention;

Fig. 4 is a flow chart showing a focus adjustment control sequence according to the second embodiment of

10   the present invention;

Fig. 5 is a graph for explaining a peak image discrimination scheme according to the second embodiment of the present invention;

Fig. 6 is a flow chart showing a focus adjustment

15   control sequence according to the third embodiment of the present invention;

Fig. 7 is a graph for explaining a peak image discrimination scheme according to the third embodiment of the present invention;

20   Fig. 8 is a block diagram showing an arrangement of a video camera system that adopts a focus adjustment method according to the fourth embodiment of the present invention;

Fig. 9 is a graph showing the relationship

25   between the field depth and integrated focus evaluation value in a peak image;

Fig. 10 is a flow chart showing a focus adjustment control sequence according to the fourth embodiment of the present invention;

Fig. 11 is graph for explaining a peak image discrimination scheme according to the fourth embodiment of the present invention;

Fig. 12 is a flow chart showing a focus adjustment control sequence according to the fifth embodiment of the present invention;

Figs. 13A and 13B are graphs for explaining a peak image discrimination scheme according to the fifth embodiment of the present invention;

Fig. 14 is a block diagram showing an arrangement of a video camera system that adopts the conventional integration AF method;

Fig. 15 is a graph showing an example of an integrated focus evaluation value in a normal object;

Fig. 16 is a graph showing an example of an integrated focus evaluation value in a peak image;

Fig. 17 is a view showing an example of an image that appears on a frame upon sensing a peak image;

Fig. 18 is a view showing an example of an image that appears on a frame upon sensing a peak image;

Fig. 19 is a block diagram showing an arrangement of a video camera system that adopts the conventional peak AF method;

Fig. 20 is a graph showing an example of a peak focus evaluation value in a peak image;

Figs. 21A and 21B are graphs respectively showing the luminance signal for one horizontal line, and the

5 output from a high-pass filter; and

Figs. 22A and 22B are graphs respectively showing the luminance signal for one horizontal line, and the output from a high-pass filter.

10 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will be described in detail in accordance with the accompanying drawings.

[First Embodiment]

15 The first embodiment of the present invention will be described first with reference to Figs. 1 to 3.

Fig. 1 is a block diagram showing an arrangement of a video camera system that adopts a focus adjustment method according to the first embodiment. The same

20 reference numeral in Fig. 1 denote the same parts as in the arrangement of the conventional video camera system shown in Fig. 14, and a detailed description thereof will be omitted. A characteristic feature of the video camera system in the first embodiment lies in

25 operations of a focus evaluation value processor 220 capable of outputting an integrated focus evaluation

value and peak focus evaluation value, an exposure evaluation value processor 230 capable of outputting the average and peak luminance values of a frame, and a camera controller 240 which receives these values.

5   A luminance signal which is output from an A/D converter 108 and input to the focus evaluation value processor 220 undergoes a process for extracting a predetermined high-frequency component from the luminance signal by a high-pass filter 221. Then, a
10   distance measurement range gate 222 executes a process for extracting only signal components within a predetermined distance measurement range from a frame. A line peak hold circuit 223 holds peaks of the extracted signal components in units of horizontal scan
15   lines. An integrator 224 integrates peak values in units of scan lines within the distance measurement range, and outputs an integrated focus evaluation value. The output from the distance measurement range gate 222 is also input to a peak hold circuit 225 to extract the
20   maximum high-frequency component within the distance measurement range. This value is called a peak focus evaluation value. The values of the integrator and peak hold circuit are reset for each frame, and the integrated focus evaluation value and peak focus
25   evaluation value for each frame can be output to the camera controller 240.

The exposure evaluation value processor 230 executes a process for extracting only a signal within a predetermined photometry range from a frame using a photometry range gate 231 with respect to the luminance signal input from the A/D converter 108. The luminance signal extracted by the photometry range gate 231 is input to an integrator 232, which outputs an average luminance signal obtained by summing up and averaging luminance signal components in the photometry range to the camera controller 240. Also, the luminance signal extracted by the photometry range gate 231 is input to a peak hold circuit 233, which outputs a maximum luminance signal within the photometry range to the camera controller 240.

Fig. 2 is a flow chart showing the AF focus adjustment control sequence executed by the camera controller 240 using these input signals.

An average luminance value Yavr and peak luminance value Ypeak are read (step S200), and it is checked if the peak luminance value Ypeak is higher than a predetermined value Yth1 (step S201). If the peak luminance value Ypeak is lower than the predetermined value Yth1, the object is unlikely to be a high-luminance object or point light source, and it is determined that the object is a normal image. Hence, a process for reading the integrated focus evaluation

value output from the integrator 224 is executed (step S210).

On the other hand, if it is determined in step S201 that the peak luminance value Ypeak is higher than the predetermined value Yth1, it is checked if the average luminance value Yavr output from the integrator 232 is very low, i.e., if the average luminance value Yavr is lower than a predetermined value Yth2 (step S202). If average luminance value Yavr is lower than the predetermined value Yth2, since it is determined that the object is a peak image (night scene or the like), a process for reading a peak focus evaluation value output from the peak hold circuit 225 is executed (step S220). Fig. 3 is an explanatory view showing an example of a peak image discrimination scheme based on the average luminance value Yavr and peak luminance value Ypeak. A condition that the peak luminance value Ypeak is not low in step S201 and the average luminance value Yavr is very low in step S202 corresponds to region 1 shown in Fig. 3.

If it is determined in step S202 that the average luminance value Yavr is not lower than the predetermined value Yth2, it is checked if the peak luminance value Ypeak is very high, i.e., it is higher than a predetermined value Yth3 (Yth3 > Yth1) (step S203). If the peak luminance value Ypeak is higher

than the predetermined value Yth3, it is checked if the average luminance value Yavr is lower than a predetermined value Yth4 (Yth4 > Yth2) (step S204).

If it is determined in step S204 that the average luminance value Yavr is lower than the predetermined value Yth4, i.e., if the peak luminance value Ypeak is very high and the average luminance value Yavr is low to some extent, it is determined that the object is a peak image such as an image of sunbeams coming through branches of trees or the like, and the process for reading a peak focus evaluation value is executed in step S220. This condition corresponds to region 2 shown in Fig. 3.

When the object does not satisfy the condition of region 1 or 2, i.e., if the peak luminance value Ypeak is low (NO in step S201 or S203) or both the average luminance value Yavr and peak luminance value Ypeak are high (NO in step S204), it is determined that the object is a normal image, and the process for reading the integrated focus evaluation value is executed in step S210. The condition of the normal image corresponds to region 3 in Fig. 3.

It is checked based on the average luminance value Yavr and peak luminance value Ypeak in the aforementioned sequence if the object is a peak or normal image. If it is determined that the object is a

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normal image, an AF process is done using the integrated focus evaluation value; otherwise, an AF process is done using a peak focus evaluation value (step S230).

In this manner, in case of an object such as a night scene, point light source, or the like (peak image) that poses a problem in the conventional integration AF method, correct focus adjustment control can be done using the peak focus evaluation value. In case of a normal image, since focus adjustment control is done based on the integrated focus evaluation value, stable focus adjustment can be made.

Since an object is discriminated in this manner, and AF control optimal to each object is done, a system which has merits of both the integration and peak AF methods can be implemented. That is, according to the first embodiment, correct focus adjustment can be done not only in a normal image but also in a peak image.

[Second Embodiment]

The second embodiment of the present invention will be described below with reference to Figs. 4 and 5.

The second embodiment is characterized in that a peak image is discriminated based on a luminance signal using a scheme different from that in the first embodiment.

Fig. 4 is a flow chart showing the focus
adjustment control sequence according to the second
embodiment of the present invention, and Fig. 5 is an
explanatory view showing the peak image discrimination
5   scheme. In Fig. 4, the sequence in step S200 and steps
S210 to S230 is the same as those in Fig. 2.

An average luminance value Yavr and peak
luminance value Ypeak are read in step S200, and it is
checked in step S201B if the peak luminance value Ypeak
10   and average luminance value Yavr satisfy:

$$Ypeak > K1 \times Yavr + Yth5 \qquad\qquad ...(1)$$

where the coefficient K1 is the ratio between the peak
luminance value Ypeak and average luminance value Yavr,
and corresponds to the slope of a straight line L1 in
15   Fig. 5. Also, the predetermined value Yth5 is an
offset of the straight line L1, and corresponds to Yth5
in Fig. 5. In the second embodiment, if the peak
luminance value is expressed by 8-bit data, since the
maximum level is 255, the slope K1 is given by:

20       $$K1 = (255 - Yth5)/Yth6 \qquad\qquad ...(2)$$

The relationship that satisfies this condition
corresponds to a peak image region shown in Fig. 5. An
object within this region undergoes an AF process using
a peak focus evaluation value. On the other hand, if
25   this condition is not satisfied, it is determined that

the object is a normal image, and an AF process is done using an integrated focus evaluation value.

As described above, according to the second embodiment, since the peak focus evaluation value is used in focus adjustment control for an object such as a night scene, point light source, or the like (peak image) that poses a problem in the conventional integration AF method, accurate focus adjustment is done even in a peak image. Since the integrated focus evaluation value is used in focus adjustment control for a normal image, stable focus adjustment can be assured.

[Third Embodiment]

The third embodiment of the present invention will be described below with reference to Figs. 6 and 7.

The third embodiment is characterized in that a peak image is discriminated based on a luminance signal using a scheme different from that in the first and second embodiments.

The third embodiment uses the ratio between the average luminance value Yavr and peak luminance value Ypeak and offset as conditions as in the second embodiment, but is different from the scheme of the second embodiment in that a plurality of ratios are used.

Fig. 6 is a flow chart showing the focus adjustment control sequence according to this embodiment, and Fig. 7 is an explanatory view showing the peak image discrimination method. Step S200 and steps S210 to S230 in Fig. 6 are the same as those shown in Fig. 2 explained in the first embodiment.

When an average luminance value Yavr and peak luminance value Ypeak are read, it is checked if these average luminance value Yavr and peak luminance value Ypeak satisfy a first condition:

$$Ypeak > K2 \times Yavr + Yth7 \qquad \ldots (3)$$

that is, if luminance data falls within a peak image region shown in Fig. 7 (step S201C). In inequality (3), the coefficient K2 is the ratio between the average luminance value Yavr and peak luminance value Ypeak, and corresponds to the slope of a straight line L2 in Fig. 7. Also, the predetermined value Yth7 corresponds to an offset of the straight line L2 shown in Fig. 7. In the third embodiment, if the peak luminance value Ypeak is expressed by 8-bit data, since the maximum level is 255, the slope K2 is given by:

$$K2 = (255 - Yth7)/Yth8 \qquad \ldots (4)$$

If it is determined in step S201C that the luminance data fall within the peak image region that satisfies inequality (3), a peak focus evaluation value is read

in step S220, and an AF process is executed in step
S230.

On the other hand, if it is determined in step
S201C that the luminance data do not satisfy inequality
(3), it is checked in step S202C if the luminance data
satisfy a second condition:

$$Ypeak > K3 \times Yavr + Yth9 \qquad \ldots (5)$$

where the coefficient K3 is the ratio between the
average luminance value Yavr and luminance peak value
Ypeak, and corresponds to the slope of a straight line
L3 in Fig. 7. Also, the predetermined value Yth9
corresponds to an offset of the straight line L3 shown
in Fig. 7. In the third embodiment, if the peak
luminance value Ypeak is expressed by 8-bit data, since
the maximum level is 255, the slope K3 is given by:

$$K3 = (255 - Yth9)/Yth10 \qquad \ldots (6)$$

If this second condition is satisfied, it is also
determined that the object is a peak image. A peak
focus evaluation value is read in step S220, and an AF
process is done using the peak focus evaluation value
in step S230. If the second condition is not satisfied
either, it is determined that the object is a normal
image. An integrated focus evaluation value is read in
step S210, and an AF process is done using the
integrated focus evaluation value.

As described above, according to the third
embodiment, since the peak focus evaluation value is
used in focus adjustment control for an object, such as
a night scene, point light source, or the like (peak
5   image) that poses a problem in the conventional
integration AF method, since the peak focus evaluation
value is used in focus adjustment control, accurate
focus adjustment can be done even in a peak image.
Since the integrated focus evaluation value is used in
10   focus adjustment control for a normal image, stable
focus adjustment can be assured.

[Fourth Embodiment]

The fourth embodiment of the present invention
will be described below with reference to Figs. 8 to 11.

15   Fig. 8 is a block diagram showing an arrangement
of a video camera system according to the fourth
embodiment. The same reference numerals in Fig. 8
denote the same parts as in the arrangement shown in
Fig. 1, and a detailed description thereof will be
20   omitted.

The fourth embodiment is characterized in that
the output from an iris position detector 250 for
detecting the aperture value of the iris, and zoom
position information (focal length information) are
25   used in peak image discrimination. The zoom position
information can be detected based on a signal such as a

stepping motor address for driving the zoom lens, which
is output from the camera controller 240 to the zoom
lens driver 111. On the other hand, the iris position
detector 250 comprises a Hall element or the like, and
5   outputs a voltage corresponding to the aperture value
of the iris to the camera controller 240.

The reason why information of the iris and focal
length is added to peak image discrimination will be
explained below.

10   In general, the field depth decreases with
increasing focal length; the field depth increases with
decreasing focal length. On the other hand, when the
iris opens, the field depth decreases; otherwise, the
focal depth increases. When the deviation of an object
15   from the in-focus position remains the same, the
defocus level becomes large when the field depth is
shallow; the defocus level is small when the field
depth is deep.

Fig. 9 shows the relationship between the field
20   depth and integrated focus evaluation value in a peak
image. As shown in Fig. 9, even in a peak image, when
the field depth is deep, a peak of the integrated focus
evaluation value appears at a correct in-focus position
P0.

25   That is, even when it is determined based on the
peak luminance value and average luminance value that

the object is a peak image, if the field depth is deep, focus adjustment can be done using the integrated focus evaluation value, depending on the focal length and iris.

5   In the fourth embodiment, the output from the iris position detector 250 and zoom position information (focal length information) are used in peak image discrimination for the aforementioned reasons.

Fig. 10 is a flow chart showing the focus
10   adjustment process sequence according to the fourth embodiment.

A peak luminance value Ypeak, average luminance value Yavr, zoom position data, and iris position data are read (step S300). It is checked if the peak
15   luminance value Ypeak is higher than a predetermined value Yth11 (step S301).

If it is determined that the peak luminance value Ypeak is lower than the predetermined value Yth11, since the object is unlikely to be a high-luminance
20   object or point light source, it is determined that the object is a normal image irrespective of the iris and zoom states, and a process for reading an integrated focus evaluation value is executed (step S310). Then, focus adjustment is executed using the integrated focus
25   evaluation value (step S330). The reason why neither the iris nor zoom states are considered in the result

in step S301 is that such object with a low peak
luminance value Ypeak is unlikely to be a peak image
irrespective of the zoom and iris states.

If it is determined in step S301 that the peak
5   luminance value Ypeak is higher than the predetermined
value Yth11, it is checked if the average luminance
value Yavr is very low, i.e., if the average luminance
value is lower than a predetermined value Yth12 (step
S302). If the average luminance value Yavr is lower
10   than the predetermined value Yth12, it is determined
that the object is a peak image irrespective of the
iris and zoom states, a peak focus evaluation value is
read (step S320), and focus adjustment is done using
the peak focus evaluation value (step S330). The
15   reason why neither the iris nor zoom states are
considered is that the object is highly likely to be a
peak image irrespective of the zoom and iris states.

If it is determined in step S302 that the average
luminance value Yavr is higher than the predetermined
20   value YTh12, it is checked if the peak luminance value
Ypeak is higher than a predetermined value Yth13 which
is higher than the predetermined value Yth11 (step
S303), and if the average luminance value Yavr is lower
than a predetermined value Yth14 larger than the
25   predetermined value Yth12 (step S304). If the peak
luminance value Ypeak is lower than the predetermined

value Yth13 or if the average luminance value Yavr is higher than the predetermined value Yth14, it is determined that the object is a normal image. The process for reading an integrated focus evaluation value is executed in step S310, and focus adjustment is done using that integrated focus evaluation value in step S330.

If the peak luminance value Ypeak is higher than the predetermined value Yth13 and the average luminance value Yavr is lower than the predetermined value Yth14, the zoom position corresponding to the focal length is compared with a predetermined threshold value Zth1 to check if the zoom position (Zoom) is at the telephoto side with a long focal length (step S305). If the zoom position (Zoom) is smaller than the predetermined value Zth1, i.e., is not at the telephoto side, the process for reading an integrated focus evaluation value is executed in step S310, and focus adjustment is done using that integrated focus evaluation value in step S330.

If the zoom position is at the telephoto side, it is checked if the aperture value of the iris is larger than a predetermined threshold value Ith1 (step S306). If it is determined that the aperture value of the iris is smaller than the predetermined threshold value Ith1, the process for reading an integrated focus evaluation

value is executed in step S310, and focus adjustment is
done using that integrated focus evaluation value in
step S330. On the other hand, if it is determined in
step S306 that the aperture value of the iris is larger
5   than the predetermined threshold value Ith1, since it
is determined that the object is a peak image and the
field depth is shallow, the process for reading a peak
focus evaluation value is executed in step S320, and
focus adjustment is done using the peak focus
10   evaluation value in step S330.

Fig. 11 is an explanatory view showing the peak
image discrimination scheme in the aforementioned
sequence. In Fig. 11, a region with a shallow field
depth, which satisfies the conditions in steps S305 and
15   S306, corresponds to region B.

As described above, according to the fourth
embodiment, since the peak focus evaluation value is
used in focus adjustment control for an object such as
a night scene, point light source, or the like (peak
20   image) that poses a problem in the conventional
integration AF method, accurate focus adjustment is
done even in a peak image. Since the integrated focus
evaluation value is used in focus adjustment control
for a normal image, stable focus adjustment can be
25   assured. Furthermore, since the fourth embodiment
refers to the zoom and iris position information, an

object of a peak image, which is hard to discriminate using the integrated focus evaluation value, can be discriminated more accurately.

[Fifth Embodiment]

5   The fifth embodiment of the present invention will be described below with reference to Figs. 12 and 13.

The fifth embodiment is characterized in that a peak image is discriminated based on a luminance signal
10   using a scheme different from that in the fourth embodiment.

Fig. 12 is a flow chart showing the focus adjustment control sequence according to the fifth embodiment, and Figs. 13A and 13B are explanatory views
15   for explaining the peak image discrimination scheme. The processing sequence in steps S300 to S304 and steps S310 to S330 in Fig. 12 are the same as those in Fig. 10 explained in the fourth embodiment mentioned above.

20   If it is determined in step S304 that the average luminance value Yavr is lower than the predetermined value Yth14, it is checked in step S307 if the region of interest has a shallow field depth, i.e., if iris position data Iris and zoom position data Zoom satisfy:

25       $\text{Iris} > K4 \times \text{Zoom} + \text{Ith3}$ ...(7)

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where the coefficient K4 is the ratio between the zoom position data Zoom and iris position data Iris and corresponds to the slope of a straight line L4 shown in Fig. 13A, and Ith3 corresponds to an offset of the straight line L4. In the fifth embodiment, if the zoom position data and iris data are 8-bit data, since their maximum level is 255, the slope K4 is given by:

$$K4 = -(255 - Ith2)/(255 - Zth2) \qquad ...(8)$$

If inequality (8) holds, it is determined that the field depth is shallow. This state corresponds to region B in Fig. 13A.

If the conditions in steps S301 to S304 are satisfied, and it is determined in step S307 that the field depth is shallow, since it is determined that the object is a peak image, a process for reading a peak focus evaluation value is executed in step S320, and focus adjustment is done using that peak focus evaluation value in step S330.

Even when the conditions in steps S301 to S304 are satisfied to determine that the object is a peak image candidate, if the condition in step S307 is not satisfied, since it is determined that the object is a normal image, the process for reading the integrated focus evaluation value is executed in step S310, and an AF process is done using that integrated focus evaluation value in step S330.

As described above, according to the fifth
embodiment, since the peak focus evaluation value is
used in focus adjustment control for an object such as
a night scene, point light source, or the like (peak

5   image) that poses a problem in the conventional
integration AF method, accurate focus adjustment is
done even in a peak image. Also, since the fifth
embodiment refers to the zoom and iris position
information, an object of a peak image, which is hard

10   to discriminate using the integrated focus evaluation
value, can be discriminated more accurately.

Note that the field depth discrimination method
is not limited to that shown in Fig. 13A. For example,
two conditions (peak image region discrimination using

15   straight lines L5 and L6) may be used, as shown in
Fig. 13B.
[Other Embodiment]

Note that, in the aforesaid embodiments, signals
to be used for focus adjustment are formed from a high-

20   frequency component of image signals within the same
area by performing two signal forming methods for focus
adjustment. However, signals to be used for focus
adjustment may be formed from a high frequency
component of image signals in two different areas in

25   this invention.

Further, one of the two signals obtained by the

two different signal forming methods for focus

adjustment is selectively used, however, both of the

two signals may be used by applying weights on these

two signals, and signals formed by 3 or more different

5   signal forming methods for focus adjustment may be used.

Further, in the above embodiments, the signal

forming methods for focus adjustment are changed

depending upon the result of photometry, however, other

operations for focus adjustment, such as operation

10   speed of lens for focus adjustment, may be changed.

Further, another evaluation photometry methods

different from those disclosed in the above embodiments,

and another signal forming method for focus adjustment

and focus adjustment method different from those

15   disclosed in the above embodiments may be used in this

invention.

Further, both of the focal length and a state of

an iris are taken into consideration upon peak image

judgement, however, one of these may be taken.

20   Further, software configuration and hardware

configuration disclosed in the above embodiments may be

exchanged.

It should be noted that the present invention

includes combinations of the aforesaid embodiments or

25   technical elements disclosed therein.

Further, the present invention also includes an

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apparatus, formed by all or a part of the apparatuses
disclosed in the embodiments of the present invention,
which can be used either individually, with another
apparatus, or within another apparatus.

5   Further, the present invention is applicable to:
various types of cameras, such as an electronic camera
for sensing a moving and/or a still image, a camera
using a silver-halide film, a single-lens reflex camera,
a leaf shutter camera, and a monitor camera; an image

10   sensing apparatus other than cameras; an image reading
apparatus; an optical apparatus; and the like; an
apparatus applied to cameras, an image sensing
apparatus, an image reading apparatus, an optical
apparatus, and the like; elements forming the foregoing

15   apparatuses; control method of the foregoing
apparatuses; and a computer program product for
providing the control method of the aforesaid processes
to a computer system or apparatus (e.g., a personal
computer), reading the program codes, by a CPU or MPU

20   of the computer system or apparatus, from the storage
medium, then executing the program.

In this case, the program codes read from the
storage medium realize the functions according to the
embodiments, and the storage medium storing the program

25   codes constitutes the invention.

Further, the storage medium, such as a floppy

disk, a hard disk, an optical disk, a magneto-optical disk, CD-ROM, CD-R, a magnetic tape, a non-volatile type memory card, and ROM can be used for providing the program codes.

5   Furthermore, besides aforesaid functions according to the above embodiments are realized by executing the program codes which are read by a computer, the present invention includes a case where an OS (operating system) or the like working on the

10   computer performs a part or entire processes in accordance with designations of the program codes and realizes functions according to the above embodiments.

Furthermore, the present invention also includes a case where, after the program codes read from the

15   storage medium are written in a function expansion card which is inserted into the computer or in a memory provided in a function expansion unit which is connected to the computer, CPU or the like contained in the function expansion card or unit performs a part or

20   entire process in accordance with designations of the program codes and realizes functions of the above embodiments.

The present invention is not limited to the above embodiments and various changes and modifications can

25   be made within the spirit and scope of the present invention. Therefore to apprise the public of the

scope of the present invention, the following claims

are made.